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VERTICAL PROFILE OF ^{210}Pb IN AN ICE CORE FROM THE HØGHETTA ICE DOME IN SPITSBERGEN

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Abstract: The concentration of ^{210}Pb in the ice core from the top of Høghetta ice dome in northern Spitsbergen was measured and its vertical profile was obtained. The ^{210}Pb activity at the surface, 6.62±0.14 dpm/kg, decreased exponentially with depth to 3.29±0.07 dpm/kg at about 10 m depth. Although the activities of ^{210}Pb between 10 m and 65 m were nearly constant, the activity suddenly decreased to 0.10±0.01 dpm/kg at 70 m depth. Below 70 m, the activities of ^{210}Pb were nearly constant and its average concentration from 70 m to 85 m was 0.09±0.01 dpm/kg. One possible explanation of this result is the atmospheric flux of mineral particles which include ^{238}U, parent of ^{210}Pb, to the surface layer of the ice dome changed at boundary between 65 m and 70 m. Another is that the ^{210}Pb between 10 m and 65 m was transported from upper layer of the ice dome by melting water or by ice flow.

1. Introduction

The Japanese Arctic Glaciological Expedition (JAGE-87) conducted successful ice core drilling at the top of the Høghetta ice dome (79°17′N, 16°50′E, 1200 m a.s.l.) in northern Spitsbergen (WATANABE and FUJII, 1988) in 1987. They obtained complete ice core samples down to the bedrock at 85.61 m depth. *In-situ* measurement of pH and EC (KAMIYAMA *et al.*, 1989), observation of air bubbles (KAMEDA *et al.*, 1989) and sand particles (FUJII *et al.*, 1990) had already been performed, giving valuable information about the paleoenvironment of northern Spitsbergen.

A natural radionuclide, ^{210}Pb (half-life 22.3 years), is a member of the ^{238}U series. The brief decay scheme after ^{226}Ra is cited together with the half-lives of daughter nuclides as follows:

$$^{226}\mathrm{Ra} \xrightarrow[1620\ \text{years}]{} {}^{222}\mathrm{Rn} \xrightarrow[3.82\ \text{days}]{} \text{short lived nuclides} \xrightarrow[22.3\ \text{years}]{} {}^{210}\mathrm{Pb} \xrightarrow{} {}^{210}\mathrm{Bi} \xrightarrow[5.01\ \text{days}]{} {}^{210}\mathrm{Po} \xrightarrow[138\ \text{days}]{} {}^{206}\mathrm{Pb}\ (\text{stable})$$

Radon-222, which is produced by the decay of ^{226}Ra in soil, migrates toward the earth's surface and escapes into the atmosphere. Then the ^{222}Rn decays with a relatively short lifetime and produces ^{210}Pb in the atmosphere. The ^{210}Pb and its

daughter nuclides are isotopes of metals having low vapor pressures at room temperature and, thus, exist as a solid form of aerosols in the atmosphere. These aerosols containing ^{210}Pb are removed from the atmosphere by wet or dry deposition and deposited on the earth's surface including the Høghetta ice dome in the Arctic region. The activity of the ^{210}Pb then decreases as a function of time at a rate controlled by its half-life. Therefore, we can use ^{210}Pb in the ice core not only as an indicator of air-borne terrestrial particles but also as a geochronometer. In this study we present the results of the analysis of ^{210}Pb in the ice core from the Høghetta ice dome and consider its vertical profile.

2. Analytical Method

As the detailed sampling (WATANABE and FUJII, 1988; FUJII *et al.*, 1990) and analytical (SUZUKI *et al.*, 1991) methods have already been published, we only outline it.

Seventeen samples were picked up from top to 85.5 m depth of the core, and contamination were during the drilling removed by cutting the outer 0.5 cm of each block off. Approximately 1 kg of the sample was melted in a glass beaker. The solution was acidified with HNO_3 and Pb tracer added. After 6 hours or more, Pb and Po in this solution were concentrated by the $CaCO_3$ coprecipitation method. The precipitate was filtered and dissolved in 0.5M HCl. And then the initial ^{210}Po in the sample was removed by electroplating onto the silver disc at 80°C for more than 3 hours. The remaining solution was diluted to exactly 50 m*l* of 2M HCl solution. The chemical yield of Pb was determined from a 1 m*l* aliquot of this solution by atomic absorption spectrophotometry. Then approximately 1 dpm of ^{209}Po tracer was added to the solution and stored for more than 3 months.

Polonium-210 produced from ^{210}Pb during storage and ^{209}Po from tracer were electroplated onto a silver disc by the procedure described above. The α-activities emitted from each nuclide were measured by an α spectrometer consisting of silicon surface-barrier detectors and a multichannel pulse-height analyzer. The concentration of ^{210}Pb was calculated from the chemical yield of Pb and the ^{210}Po/^{209}Po activity ratio.

3. Results and Discussion

The vertical profile of ^{210}Pb in the ice core is shown in Fig. 1. The concentration of ^{210}Pb at the top of the ice core was 6.62±0.14 dpm/kg. This value is comparable with the concentration of ^{210}Pb in rainwater in the United Kingdom (1.4–9.3 dpm/kg, BURTON and STEWART, 1960) and at New Haven, USA (1.8–17.1 dpm/kg, TUREKIAN *et al.*, 1983). The ^{210}Pb activity at the surface decreased exponentially with depth to 3.29±0.07 dpm/kg at about 10 m depth. Although the activities of ^{210}Pb between 10 m and 65 m were nearly constant (average 3.11±0.04 dpm/kg), the activity suddenly decreased to 0.10±0.01 dpm/kg at 70 m depth. Below 70 m, the activities of ^{210}Pb were nearly constant and

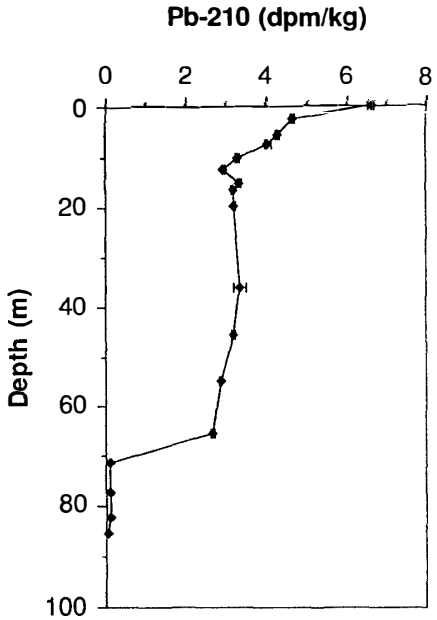

Fig. 1. Vertical profile of ^{210}Pb in the ice core from the Høghetta ice dome, northern Spitsbergen. Horizontal bars indicate the counting error.

its average concentration from 70 m to 85 m was 0.09±0.01 dpm/kg. The activity of the deepest sample was 0.05±0.01 dpm/kg, this value agrees well with the activity of ^{210}Pb in ice which was obtained at 63–76 m depth in the Greenland ice sheet (CROZAZ and LANGWAY, 1966). We can consider two possible explanations of this result. One is the atmospheric deposition rate of mineral particles which include ^{238}U, parent of ^{210}Pb, to the surface layer of the ice dome increased at boundary between 65 m and 70 m. If we assume the radioactive equilibrium exists between ^{210}Pb and ^{238}U in mineral particles in the ice core and the activity of ^{238}U in these particles is 2 dpm/g, more than 1 g of mineral particles have to be contained in 1 kg of ice to maintain 3 dpm/kg of ^{210}Pb activity. However, we did not observe so many particles in the ice samples. Another possibility is that ^{210}Pb between 10 m and 65 m was transported from the upper layer of the ice dome by melting water or by ice flow. SUZUKI *et al.* (1991) estimated the accumulation rate of the ice at the top of the Høghetta ice dome as 18±4 cm-ice/yr on the assumption that the activity of ^{210}Pb between 10 m and 65 m originate in mineral particles. They obtained the concentration of ^{210}Pb which is not supported by ^{238}U in mineral particles ($^{210}Pb_{unsupported}$) by subtracting the average concentration between 10 m and 65 m from upper 4 data. However, if we consider that the ^{210}Pb between 10 m and 65 m was transported from the upper layer of the ice dome, the concentration gradient of ^{210}Pb from the surface to 10 m depth does not represent only decay of $^{210}Pb_{unsupported}$, hence, we can not determine the ice accumulation rate at this site. Further consideration of the results of Al content, shapes of air bubbles, and particle counts in the ice core will be necessary to determine the reason for the discontinuity between 65 m and 70 m. Lead-210 analysis of ice cores from an other site, *e.g.* Greenland, will provide an important clue to clarify this point.

4. Conclusion

We obtained the discontinuous vertical profile of ^{210}Pb in an ice core from the Høghetta ice dome in northern Spitsbergen. This result indicates that the atmospheric deposition rate of mineral particles to the ice dome changed at a discontinuous boundary or that the ^{210}Pb moved by melting or ice flow after it was deposited on the ice dome.

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